IITRI

TECHNOLOGY APPLICATIONS TEAM

Quarterly Progress Report

IITRI Project V6102

NASA Contract NASw-1953

for the period

1 January to 31 March 1970

IIT Research Institute

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PREFACE

This report describes the activities of the IITRI Technology Applications Team during the quarter 1 January to 31 March 1970. It is presented in a new format, and includes a brief summary of all projects active on 31 March, and of the progress made during the quarter.

The objective of the TATeam is the application of aerospace-generated technology to specific problems of Mine Safety, Law Enforcement, and Water Pollution. The work is supported and monitored by the NASA Technology Utilization Division, under contract NASw-1953.

The IITRI TATeam is directed by F. Robert Hand, Research Engineer, under the management of Gerald Bay, Manager of the Technology Utilization Section at IITRI.

Respectfully submitted,

F R Hand

F. R. Hand, Director
Technology Applications Team

Approved by:

Gerald B. Bay
Manager
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SUMMARY OF ACTIVITIES FOR

1 JANUARY to 31 MARCH 1970

	MINE SAFETY	LAW EN-FORCEMENT	WATER POLLUTION	TOTAL
PROBLEMS				
Problems Accepted during the Quarter	7	8	4	19
Problems Rejected during the Quarter	3	-	-	3
TOTAL Problems Active on 31 March	14	15	4	34*
Problem Statements Prepared	3	3	1	7
SEARCHES				
Computer Searches Initiated	2	2	-	4
Other Searches Initiated**	-	-	-	-
Searches Evaluated during the Period	2	2	-	4
CONTACTS				
Contacts with User and Potential User Institutions	11	20	11	42
Contacts with NASA Field Centers	16	13	-	29
TRANSFERS				
Potential Transfers Identified to Date	3	1	1 (FLSS)	5
Transfers Claimed	-	-	-	-

* Includes one problem on Fireman's Life Support System (FLSS).
** A report on an experiment comparing the effectiveness of a manual and RDC Search - started in February and completed during March - is reproduced as Appendix A.

I. GENERAL REVIEW

The IITRI TATeam was formed and its work started in June 1969. In the first six months, June to December 1969, the emphasis was on establishing contacts and working relationships with mine safety and law enforcement agencies. Slowly, as they began to appreciate the potential of the Technology Utilization Program, these agencies began to divulge their problems. Discussion with those directly concerned led to the definition of the problems in aerospace terms, a standard Problem Statement format was adopted, and searches were made for the relevant aerospace technology applicable to the problems.

By the beginning of January 1970 the complex process of technology transfer had begun to unravel some of the problems identified in the previous six months. Meantime fresh contacts with the mine safety and law enforcement agencies had spawned a new crop of problems; investigating these and the pursuit of solutions to the earlier ones extended and knitted our relationship with NASA centers. The time was now considered propitious for an extension of the TATeam's responsibility into the field of Water Pollution. During the course of this quarter, therefore, attempts have been made to develop contacts with such agencies as the Federal Water Pollution Control Administration (FWPCA).

Progress towards the objective of the TATeam has been steady throughout the period under review. So far no actual technology transfer has been achieved but six items have been identified which may provide solutions to problems put to the team. Of these, significant progress towards transfer has been made with four. (Details are given in Section 5, page 27 of the Report.) At the end of March the remaining two were being evaluated; both appear to be of potential value.

Implicit in the work of the TATeam is the importance of contacts and liaison with the problem-originating agencies. During the quarter, our circle of contacts has been enlarged. Field offices of the Bureau of Mines at Denver and Minneapolis have been visited; so too have the police authorities in Los Angeles, New York City, Pittsburgh, and New York State, the New York State Identification and Intelligence System, New York Office of Crime Control Planning, and the Port Authority (N.Y.C.) police. Fifteen acceptable new problems have emerged as a result of these visits. Meetings with Water Pollution Control officers have been equally productive. Visits to Federal Water Quality Administration (formerly Federal Water Pollution Control Administration) field centers at Cincinnati, Ada, Oklahoma, and Corvallis, Oregon, have revealed a series of problems four of which have already been accepted.

The purpose of the TU program has also been explained to representatives of the American Iron and Steel Institute, the Soap and Detergent Association, and the American Petroleum Institute - all of whom have expressed the opinion that the TATeam might well be able to help resolve some of their water pollution difficulties, which are industry wide in nature and of public significance.

In concluding this brief summary, one point made in the two previous quarterly reports must be reiterated. All the experience of the TATeam so far confirms the precept that technology transfer is a complicated and challenging business. In the course of the period under review the IITRI TATeam has learned a great deal, and hopefully have contributed to the understanding of some aspects of the transfer process.

II. PROBLEMS

A. Problems Accepted

Nineteen new problems were accepted during the quarter: 7 on Mine Safety, 8 Law Enforcement, and 4 concerning Water Pollution.

Mine Safety

MS-7	Seismic Signal Delay
MS-9	Methane Monitor
MS-10	Stress Measurement in Rock
MS-11	Improved Oxygen Supply for Miners
MS-12	Food Supply for Trapped Miners
MS-13	Waste Disposal - Miners Trapped Underground
MS-14	Sampling and Analysis of Settled Dust

Of these the problem has been fully defined only in the case of MS-7. On March 31 the parameters of the remainder were still under consideration.

Law Enforcement

LE-6	Remote Vehicle Tracking
LE-10	Cargo Tracking
LE-11	Communications Link - Automatic Trouble Shooting
LE-12	Measurement of a Ship's Speed from a Moving Patrol Boat
LE-13	Location of Underwater Objects
LE-14	Determination of Vehicle Speed from Impact Damage
LE-15	Accident Investigation Using Photographic Information
LE-16	Transmission of Video Signals from Mobile Units

By 31 March Problem LE-6 had been defined and information relevant to a solution was being sought. But problem statements for the remaining 7 problems still have to be prepared.

Water Pollution

WP-1 Water Density

WP-2 Lake Current Velocity

WP-3 Particulate Matter Monitor

WP-4 Detection of Living and Non-Living Organisms

By March 31 a problem statement has been issued only in respect of WP-1 (See page 66).

B. Problems Rejected

Three problems were rejected during the quarter. All originated at the Bureau of Mines' Mining Research Department (Mr. Eugene Palowitch).

1. Mine Surveying Techniques

Mine surveying techniques do not provide sufficient accuracy in mapping to enable the drilling of a bore hole to be certain of reaching a predetermined position - such as that where miners have been trapped after an explosion. The requirement is to relate the mine workings to the surface contours. (Laser beam techniques are not yet feasible.)

2. Rapid Drilling Technique

When miners, trapped underground after a disaster, are located it is often necessary to drill through to them from the surface. Speed is vital to such an operation. Yet, the only equipment available is that which has been developed for drilling operations where speed is not essential. The Bureau of Mines is waiting for a report from the National Academy of Engineering on this subject. In any case, there is low probability that a solution will be found in NASA technology.

3. Desorbtion of Methane

The most serious explosive hazard in coal mines is methane, and the Bureau of Mines has been trying to measure the methane permeability of a coal bed. The requirement is for an on-the-spot measuring instrument. There is low probability that a solution will be found in NASA technology.

C. Problems Inactivated or Reactivated

No problems have been inactivated during the period under review. But Problem MS-6A has been substituted for MS-6 (which was concerned with improved batteries in coal mines). MS-6A postulates the need for a new miner's cap lamp. (The MS-6A Problem Statement was prepared during March, and a copy of it is included in this report on page 42).

D. Problem Statements Issued

Seven problem statements were prepared during the quarter:

MS-5	Communications
MS-6A	Cap Lamp
MS-8	Roof Movement
LE-2	Indented Writing
LE-7	Lightweight Gas Mask
LE-9	Rescue Equipment
WP-1	Water Density

Copies of these statements are reproduced in Appendix B on pages 35 through 68.

E. Problems Active on 31 March 1970

Thirty-four problems were under active consideration on 31 March. In the list that follows each problem has been graded in accordance with the following Status Code:

A. Problem Definition - Includes the identification of specific technology-related problems through discussions with problem originators and the preparation of functional descriptions of problems.

B. Information Searching - Information relevant to a solution is being sought by computer and/or manual information searching.

C. Problem Abstract Dissemination - An information search has revealed no potential solutions, and a problem abstract is being circulated to individual scientists and engineers at NASA centers and contractor facilities to solicit suggestions.

D. Evaluation - Potentially useful information or technology has been identified and is being evaluated by the team and/or the problem originator.

E. Potential Transfer - Information or technology has been evaluated and found to be of potential value but has not been applied.

F. Follow-up Activity - A technology transfer has been accomplished, but further activity (i.e., documentation, obtaining experimental validation of utility, continuing modification, etc.) is required.

Brief details of the problems are set out on pages 10 through 23

Mine Safety

Problem No.	Status	Problem Title
MS-1	E	Dust Monitor
MS-2	E	Explosion Detector
MS-3	E	Air-Flow Measurement
MS-4	E	Explosion Quenching
MS-5	C	Communications
MS-6A	A	Cap Lamp
MS-7	B	Seismic Signal Delay
MS-8	C	Roof Movement
MS-9	A	Methane Monitor
MS-10	A	Stress Measurement in Rocks
MS-11	A	Oxygen Supply

Problem No.	Status	Problem Title
MS-12	A	Food Supply
MS-13	A	Waste Disposal
MS-14	A	Settled Dust
Law Enforcement		
LE-1	B	Mini Antenna
LE-2	E	Indented Writing
LE-3	C	Speed Measurement
LE-4	C	Age of Ink
LE-5 (cancelled)		
LE-6	B	Remote Vehicle Tracking
LE-7	B	Face Mask
LE-8	B	Remote Surveillance
LE-9	C	Rescue Equipment
LE-10	A	Cargo Tracking
LE-11	A	Communications Link: Automatic Trouble Shooting
LE-12	A	Measurement of Ship's Speed From Moving Patrol Boat
LE-13	A	Location of Underwater Objects
LE-14	A	Determination of Vehicle Speed From Impact Damage
LE-15	A	Accident Investigations Using Photographic Information
LE-16	A	Transmission of Video Signals From Mobile Units
Fire Department		
-	E	Fireman's Life Support System
Water Pollution		
WP-1	B	Water Density
WP-2	A	Lake Current Velocity
WP-3	A	Particulate Matter Monitor
WP-4	A	Detection of Living and Non-Living Organisms

MS-1, Dust Monitoring Instrument

Dust monitoring is of importance in mines. There are two types of dust which are of concern: (a) respirable dust, and (b) float dust. The respirable fraction is below 10 microns in size and the float dust fraction is from 10 to 70 microns. The latter, carried away from the working face by air currents, settles on rock surfaces from where it is picked up during a gas explosion. Instrumentation for dust monitoring should be able to distinguish between combustible and non-combustible dust. A hand-held, continuous reading instrument is preferable for use in the return system.

During January, a dust monitor developed by NASA's Electronics Research Center (ERC) was demonstrated at the Bureau of Mines' Pittsburgh Laboratory. The test showed that the instrument in its existing form was not capable of measuring dust levels as high as those likely to be encountered in a mine. But the instrument showed promise, and after modification and development it was returned to the Bureau of Mines for a trial; in March, the TATeam was given the gist of the conclusions which will be incorporated in a report to be released through the Bureau's Washington Office. It seems that the Bureau does not consider that their requirements are met by the ERC instrument. It may be used in conjunction with dust control apparatus. But it can not be used as a measurement standard.

MS-2, Explosion Detector

There are two aspects to the problem of quenching mine explosions: (a) an explosion at the mine face, (b) propagation of an explosion in the mine. In the latter, both the position and the velocity of an approaching explosion front must be computed so that the quenching mechanism can be triggered at the right instant. UV detectors which rapidly indicate the presence of an explosion have been devised but are susceptible to false signals from cap lamps or sparks. An improved detector is necessary which would respond only to the characteristics of an explosion.

A device sensitive to pressure transients was developed for NASA Marshall Space Flight Center to measure the blast at a launch pad. The prototype has not yet been delivered to NASA by the contractor, but when it is, its potential merit for use in coal mines will be assessed.

In January, Mr. R. Trimpi of NASA's Langley Research Center responded to the Problem Statement and suggested that signals from a two channel detector might <u>not</u> be sensitive to false signals. This suggestion does not represent new technology but it will be included among technical solutions considered when the TATeam's report is prepared for the Bureau of Mines.

<u>MS-3, Air-Flow Measurement</u>

A vane type anemometer or some other method of measuring wind velocity in the range below 100 feet per minute is needed. The instrument should be capable of a sensitivity of 10 feet per minute or lower, and be capable of measuring air current velocity across the entire cross-section of a tunnel way - averaging the readings taken at the nodes of a grid.

During January, Mr. R. Miner of NASA's ERC responded to our Problem Statement with a suggestion for a low speed air velocity indicator developed for NASA by the Bowles Engineering Company. This instrument relies on fluidic action for its functioning. A demonstration of the device was given at the Bureau of Mines' Pittsburgh Laboratory. At this demonstration the Bureau's representatives expressed interest in it but contended that the quantity of air which had to be supplied to the instrument in order to create fluidic action made it impractical for their purpose.

After the demonstration, however, it was discovered that an erroneous calculation had resulted in an excessive quantity of air being quoted. This information was passed to the Bureau of Mines, and a report on the Bowles air speed sensor is in the course of preparation.

MS-4, Explosion Quenching

There is a need for explosively actuated or other sudden opening type valves for use with fire extinguishing agents to rapidly extinguish a fire upon detection. A light linear shaped charge has been suggested but this presents an explosion hazard of its own.

NASA's Kennedy Space Center (Mr. L. DuGoff) responded to the Problem Statement in January with a list of references to Fire Extinguishing chemicals. Regrettably only one of these references - to work performed at the University of Florida - appeared to be applicable.

In February, Mr. R. Neumann of NASA's MSFC responded to the Problem Statement with a suggestion based on the idea of using a squib - actuated spray nozzle. An explosive charge drives a piston which compresses an inert gas to a high pressure. The pressure is released when the quenching agent is forced through the spray nozzle. Unfortunately this concept suffers from the same disadvantage as the device currently being developed by the Bureau of Mines, in that it employs an explosive charge.

MS-5, Communications

No emergency communications system is used in mines today and there is a need for a system whereby miners - trapped after an explosion - can let those on the surface know that they are alive and where they are. The problem involves the generation of a suitable signal, its propagation through a rock and soil medium, its reception, and data processing to determine where it came from.

No technology beyond the state-of-the-art has yet been identified applicable to this problem. Nor have any of the Field Centers responded to the Problem Statement.

MS-6A, Cap Lamp

Originally this requirement specified a need for improved storage batteries for miner's lamps. But a study of the problem revealed that what was really needed was a new light source capable of being incorporated within the safety helmet.

The revised Problem Statement was formulated only in late March (refer also to page 42).

MS-7, Seismic Signal Delay

To study rock bursts - a phenomenon defined as any sudden and violent expulsion of rock from its surroundings - a seismic monitoring system is needed which will record the onset of the seismic wave front.

Work on this problem during the period under review has been confined to a study of its technological parameters, prior to the preparation of the Problem Statement.

MS-8, Roof Movement Detector

Prior to collapse, the roof of a mine will slowly move or slip. The requirement is for a means of measuring the degree of this movement so that an alarm can be given when the roof rock is about to collapse.

A literature search has been conducted and evaluated. No relevant aerospace technology was identified.

MS-9, Methane Monitor

Methane gas, in concentrations of 5 to 15 per cent, represents the most serious explosive hazard in coal mines. At present methane in U. S. coal mines is monitored by methanometers developed by the U. S. Bureau of Mines. These are Wheatstone Bridge type instruments in which the change in resistance of a platinum filament is related to the methane concentration. In the United Kingdom a flame methanometer is used, which relates an increase in flame height to methane concentration. Other methods which have been used are based on conventional gas analyni, flame ionization, gas chromatography, and infrared absorption. None have proved as satisfactory in the U. S. as the existing Wheatstone Bridge type monitor. Nevertheless, it is felt that an improved instrument is needed.

This problem has been inactive since September 1969, because the TATeam has awaited the outcome of technology on problems MS-1, "Dust Monitor," and MS-3, "Air-Flow Measurement," which could form the components of an overall monitoring system. Towards the end of the quarter, however, the problem was considered and accepted as one of those which the TATeam will now actively pursue.

MS-10, Stress Measurement in Rocks

As material is removed from a mine, the weight of the soil and rock above the mine is redistributed along the tunnel roofs and the rock pillars supporting the mine. There is a need for an instrument to measure the stress in the rock so as to be able to predict potential rock bursts, crushing of pillars, or roof falls.

Like MS-9, this problem has been in suspension, but has now been activated.

MS-11, Oxygen Supply

MS-12, Food Supply

MS-13, Waste Disposal

In a post-disaster period, miners can be trapped for as long as twelve days. Life support systems must be available to them during this period of confinement, for they need food, water, and oxygen. There have been no new developments in oxygen supply equipment available to miners in two decades. The need is for either portable oxygen supply equipment which can accompany the miners as they move along the face, or a semi-portable supply system which can be stored in survival chambers located throughout the mine. In the case of the latter, there is also a need for a portable bulk head which can be moved, as the miners advance along the face, to new survival chambers.

Consideration of this problem brought the realization that there are three separate issues and requirements involved. They have been designated Problems MS-11, MS-12, and MS-13. But at 31 March they had not gone beyond the definition stage.

MS-14, Settled Dust

Coal mines are periodically dusted with crushed rock in order to suppress the coal dust which is generated during the mining process. Float dust often settles on the surface of this rock dust, and there is a need for an instrument which will sample the cross section of the rock dust to determine not only the concentration of coal dust but its distribution as it varies with depth. The upper crust of dust to a depth of one inch is of most interest.

At March 31 this problem had not gone beyond the definition stage.

LE-1, Mini Antenna

The transceivers with which the police are equipped have whip antennas which have to be extended if the radio is to operate efficiently. These antennas are awkward and inconvenient, and there are no suitable alternatives available commercially.

What is needed is an omnidirectional antenna, which does not protrude more than a couple of inches from the transceiver but which has the same radiation efficiency as the existing whip antenna.

An exploratory RECON search has been conducted and evaluated. But no applicable NASA technology has yet been identified.

LE-2, Indented Writing

Indented writing is the image of a written message which has been transferred from the original as an impression in the surface of a succeeding layer of paper or other material. This type of evidence is extremely important in analyzing bank holdup notes, crank letters and newspapers and pads left out at the scene of a crime. What is needed is a better method of recovering this writing.

In the last quarterly report we noted that an instrument developed by Metro-Physics, Inc. for the Marshall Space Flight Center might provide a solution to the problem of indented writing. Experiments by Metro-Physics, Inc. with this instrument, which uses a fiber optic sensor to detect flaws in the surface of tube flares, have shown distinct promise (see also section 5 on page 27).

LE-3, Speed Measurement

Much police work is related to traffic control, and one of the problems associated with the enforcement of traffic regulation is the determination of vehicular speed from a patrol car which is itself moving. There are systems which can determine the speed of on-coming or passing vehicles, but they require a fixed or stationary location. The only existing moving vehicle systems require considerable individual judgement. What is needed, therefore, is an improved and reliable method requiring the minimum involvement by the police officer.

So far, literature searches have not revealed any relevant technology which promises a solution. (During January, this problem was used as the basis of an aerospace literature search experiment. See page 24.)

LE-4, Age of Ink

The age and sequence of the script in a document containing more than one writing is often of critical importance in criminal investigations. Many documents in this category have been inscribed with a ball-point pen, and because of the special properties of ball-point pen inks and the percussive nature of ball-point pen writing, ink characterization and the determination of the sequence of writing is feasible.

So far, however, there is no standard method of doing this. Moreover, it is believed that ball-point pen inks are not suited to methods of differentiation of visual and microscopic examinations or by infrared and fluorescent methods..

The problem may be considered a requirement for a non-destructive method of establishing, (a) the age of ball pen writing, and (b) the sequence of different entries. A literature search has been initiated, received, and evaluated. But no relevant technology has been identified.

LE-6, Remote Vehicle Tracking

A system which will allow the surveillance of suspect vehicles could have considerable value in police intelligence work.

This problem is complicated by the need for a cheap miniature transmitter with an equivalently cheap, small, and durable power supply. The Problem Statement has not yet been written, because of the difficulty in identifying the true technology need.

LE-7, Face Mask

Most of the police casualties in civil disturbances are caused by missiles, but sometimes tear gas is also a hazard. For face protection the police currently rely on obsolescent military respirators, which are heavy, cumbersome, and restrictive; such respirators are also ineffective against CS type tear gas.

At March 31, the problem was still under consideration, and no Problem Statement had been written.

LE-8, Remote Surveillance

Searching a secluded area like a wood, or closed offices and shops is a laborious and time-consuming process for the police. When criminals are involved it can also be a dangerous one. Remote surveillance systems could extend the eyes and ears of the police and enhance their capabilities.

The real technology need in this problem has not yet been identified. Some commercial devices of the image-intensifying type, have been examined. But none of these meet the requirement for a variety of reasons (especially cost).

LE-9, Rescue Equipment

Police officers often have to extricate the bodies of people who have died or been injured in automobile accidents. To do so it is sometimes necessary to remove or shift pieces of twisted steel, and this is difficult unless the proper equipment is available. In the past, saws, hydraulic jacks, and other devices have been used. But little has been done with techniques like metal crystallization. Such techniques, it is believed, may provide the police with an extra tool and contribute to the saving of lives and limbs.

During January, the TATeam visited the Snorkel Squad #1 at the Chicago Fire Department to determine what the requirement really was. At this discussion specific tools were requested; in particular, a device capable of separating two collapsed steel members. A quick search in commercial catalogues soon revealed that such a device - an attachment to a hydraulic pump - was already on the market. This information was passed to Snorkel Squad #1, who confirmed that they already had such equipment in use. After its short-comings had been detailed, it was then possible to ascertain the real technological need. This is for: (a) improved hydraulic couplings that will withstand high pressures, and capable of quick connection, and (b) hydraulic pumps which can operate in any orientation.

A search of the aerospace literature has revealed nothing useful so far. Nor has any information been forthcoming consequent on the circulation of the Problem Statement. The next step is to conduct another literature search with an expanded strategy.

LE-10, Cargo Tracking

The incidence of freight theft - especially air freight - is high and increasing. What is needed is some means of tracking individual portions of cargo to the point at which it is disposed of by the thieves.

This problem is still being studied. No Problem Statement has yet been prepared.

LE-11, Communications Link: Automatic Trouble Shooting

The police use a data communications system to relay intelligence information between departments. On occasions technical faults interrupt this system and hinder the passage of the information. What is needed is an automatic fault-finding apparatus, incorporated in the system, which will minimize the interruption.

The problem is being studied and a Problem Statement is in the course of preparation.

LE-12, Measurement of Ship's Speed from Moving Patrol Boat

Marine police are responsible for traffic control of small boat and pleasure craft near docks and marinas. At present there is no effective method of measuring a boat's speed from the shore. (The timing of a boat over a known distance is generally not practicable because of the difficulty in establishing distance markers. Similarly the employment of a radar system similar to that used on land is fraught with difficulties due to the roll and pitch of the patrol boat carrying the radar.)

So far, this problem has not gone beyond discussions of the parameters involved. However, a preliminary Problem Statement is in the course of being written.

LE-13, Location of Underwater Objects

There is a need to locate a variety of submerged objects in harbors, rivers, and lakes. The size of such objects can range from very large to minute, and they may be metallic or non-metallic objects. In the polluted waters, of say, New York Harbor the view of underwater television cameras may be restricted to a few feet. What is needed is some device which will penetrate murky water, mud, ooze, and slime.

This problem is still under consideration.

LE-14, Determination of Vehicle Speed from Impact Damage

Determining vehicle speed from impact damage is complicated by the unknown number of variables with which the problem is beset. These will vary according to relative speeds, angle of impact, and material properties.

The problem is under consideration, and a definition of the technological need is being sought.

LE-15, Accident Investigation Using Photographic Information

This requirement is for a means to photograph the scene of an accident in such a manner that a standard form of interpretation will reveal valid information of the circumstances in which it occurred.

The problem is being studied to define the technological requirement.

LE-16, Transmission of Video Signals from Mobile Units

The police need to view remotely public gatherings where an inflammatory situation is likely to develop. Current methods of doing so rely on the use of heavy equipment whose installation advertises public interest, and which require considerable time and effort to deploy them. The requirement is for rugged, portable equipment relaying visual information to a command center by radio.

In a built-up area the problem is complicated by the fact that radio signals are reflected and channelled by buildings in their path. This prevents signals reaching a center outside the observed area.

The problem is being considered and a Problem Statement is in the course of preparation.

Fireman's Life Support System (FLSS)

This problem was a special project, initiated prior to the present contract of the TATeam. Briefly, what is needed is a new breathing apparatus. After a careful investigation of the problems involved, the TATeam concluded that sodium chlorate candles were likely to provide a practical and feasible solution. (The process of manufacturing chlorate candles which will yield oxygen of a high purity was developed under a NASA contract by the AIResearch Manufacturing Company.)

In January, considerable interest in the chlorate candle idea was expressed by Chief Neville and others of Chicago's Fire Department. This encouragement led to a meeting on January 30 of the TATeam and representatives of AIResearch Mfg. Co. At this meeting the latter appeared to be satisfied that there is a potential Fire Service Market for their chlorate candles. But they expressed the following reservations:

(a) It is possible that firemen may have some objection to breathing pure oxygen.

(b) There may be a fire hazard if breathing oxygen "overflows" in a burning building.

(c) If a means of turning off the candle system is a requirement, there may be technical production difficulties.

(d) A high quality recharge of the breathing apparatus may cost between $5 and $10.

After this meeting the TATeam discussed these reservations with Captain Blair of the Los Angeles Fire Department (LAFD), and it was learned that:

(a) Until 1962, pure oxygen was used in the LAFD; it was discontinued because bottled oxygen was expensive.

Thus - so far as the LAFD was concerned - there was unlikely to be any objection to the use of pure oxygen.

(b) When heated, compressed oxygen gas cylinders might well be a menace.

(c) A method of turning off the candles, to conserve their oxygen supply, seemed desirable.

(d) The operating costs of a chlorate candle unit would have to be much less than $10 per recharge for their use to be economically viable.

Following this discussion the TATeam studied the different methods in which the candles could be used in a FLSS. Our initial calculations suggest that the most efficient system will incorporate an oxygen accumulator tank, supplying oxygen to the firemen through a demand regulator valve.

Then, in March, we discussed chlorate candle technology with Mr. W. Smith of NASA/OART. Mr. Smith expressed his reservations on their use in a FLSS. His principle reasons were that: (1) their flow rate cannot easily be adjusted to a variable breathing demand, and (2) they discharge unacceptable contaminants. In rebuttal we have stressed that a demand-regulated system, employing an accumulator tank will cater to Mr. Smith's first objection, and that according to AIResearch reports the contamination is well below SAE standards.

These points raised by Mr. Smith have been referred to Dr. A. Chambers of the Ames Research Center, who is a recognized authority on Life Support Systems. Dr. Chambers has agreed to read the reports on our proposed FLSS and evaluate our recommendations.

<u>WP-1, Water Density</u>

In large reservoirs - where the water movement in and out is small relative to the size of the reservoir - considerable density stratification can take place. The stratification process dependent on water depth, temperature, and chloride concentration, can cause the water to become anaerobic - so rendering the water undrinkable. It may be possible to prevent this happening if the stratification can be detected. To do so a portable field measuring instrument is needed.

WP-2, Lake Current Velocity

A portable instrument to measure velocities and directions of current below the surface of lakes and reservoirs is needed.

WP-3, Particulate Matter Monitor

A simple, accurate method of measuring the suspended particulates in water is needed.

WP-4, Detection of Living and Non-Living Organisms

There is a requirement for some means of detecting and separating the living and non-living organisms (including virus and bacteria at low concentrations).

Problems WP-1, WP-2, WP-3, and WP-4 were identified in February, and by the end of the period under review none had got beyond the Problem Statement preparation phase. Only with WP-1 was a literature search organized before March 31.

III. SEARCHES

A. Searches Initiated

During the period under review computer searches were initiated on the following problems:

MS-8, Roof Movement

LE-2, Indented Writing

LE-4, Age of Ink

LE-9, Rescue Equipment

LE-6, Remote Vehicle Tracking

Subsequent to the search on MS-6 and consultation with the problem originator the scope of the problem was widened and it has now become MS-6A (page 42).

An experiment to compare the effectiveness of a manual and RDC search was also conducted during February and March. A report on this experiment subtitled "Search Experiments" is reproduced as Appendix A.

B. Evaluations of Searches

The results of three searches on two problems were evaluated during the quarter.

Problem	Citations Culled	Citations Relevant
MS-8, Roof Movement Detector	40	2
LE-9, Rescue Equipment	40	8
LE-2, Indented Writing	41	7

Results of a search on problem LE-3, Speed Measurement, were as follows:

Citations Culled: KASC 650
ARAC 102

These citations have yet to be evaluated.

C. Evaluations in Progress

Problem	Citations Culled
LE-3, Speed Measurements	650

It is hoped to complete this evaluation during April.

This problem was also used as the basis of a literature search experiment, reported in our February monthly report (report reproduced as Appendix C).

IV. CONTACTS

During January our contacts with user and potential user institutions were concerned mainly with briefings regarding our activities. By March, however, the emphasis had changed, and we were occupied primarily with problems that had emerged from earlier discussions. This was to be expected. For, gradually, as the nature of our work - together with the potential of technology transfer and our own capacity and willingness to help - becomes better known, the need for soliciting additional user institutions will grow less and problems may be expected to flow to us in an ever-growing stream.

Our contacts with NASA centers during the quarter were, as always, cordial and fruitful. Some of the items contributed by NASA researchers were not always applicable to the problems for which they were intended; but this was to be expected and we would not wish to damp the enthusiasm that exists.

V. TECHNOLOGY IDENTIFIED

At the end of March, six items of aerospace technology, relevant to our problems had been identified. Of these six items, significant steps have been taken towards the transfer of four.

(a) Sodium chlorate candles were developed by NASA as an oxygen supply during lunar exploration. The IITRI TATeam believes that these candles can be incorporated in a new lighter, more durable breathing apparatus for use by firemen (Problem FLSS).

(b) An aerosol particle analyzer was developed at the NASA Electronics Research Center to monitor dust in Apollo spacecraft. This has been tested by the Bureau of Mines for consideration as a means of measuring the quantity of dust prevalent in the atmospheres of coal mines. (Problem MS-1)

(c) A wind sensor has been developed for the NASA Electronics Research Center, for use with an air speed indicator in V/STOL aircraft. This has been demonstrated to the Bureau of Mines at their Pittsburgh Laboratory for consideration as an instrument suited to the measurement of low velocity air currents in mine galleries (Problem MS-3).

(d) A fiber optic surface gauge, made for NASA's Marshall Space Flight Center to inspect the surface of tubing flares in Saturn rocket engines, may be adapted for use in the recovering of indented writing. (Problem LE-2).

The other two items of aerospace technology relevant to our problems are still being evaluated. These are: (a) a pressure transient sensor for use in detecting explosions in coal mines (Problem MS-2), and (b) a squib-actuated spray nozzle for the rapid dispersal of an explosion quenching agent (Problem MS-4).

VI. PROPOSED PROGRAM FOR THE QUARTER ENDING 30 JUNE 1970

A. New Problems

Identify new problems with accent on Water Pollution, our new area of investigation.

B. Problem Statements

To be drafted and finalized for:

MS-9	Methane Monitor
MS-10	Stress Measurement in Rock
MS-11	Improved Oxygen Supply
MS-12	Food Supply for Trapped Miners
MS-13	Waste Disposal - Miners Trapped Underground
MS-14	Sampling and Analysis of Settled Dust
LE-10	Cargo Tracking
LE-11	Communications Link: Automatic Trouble Shooting
LE-12	Measurement of Ship's Speed from Moving Patrol Boat
LE-13	Location of Underwater Objects
LE-14	Determination of Vehicle Speed from Impact Damage
LE-15	Accident Investigations Using Photographic Information
LE-16	Transmission of Video Signal from Mobile Units
WP-2	Lake Current Velocity
WP-3	Particulate Matter Monitor
WP-4	Detection of Living and Non-Living Organisms

To be finalized for:

MS-6A	Cap Lamp for Miners
LE-7	Face Mask
WP-1	Water Density

C. Active Problems

Computer Searches: Initiate and evaluate computer searches for all the problems listed in B.

D. Potential Transfers

1. Assess the possibility of a Technology Transfer in respect of LE-2, Indented Writing, consequent on the results of the experiments now being conducted by Metro-Physics, Inc.

2. Pursue with the Bureau of Mines the results obtained in the trials of the MS-1, Dust Monitor. An official report, including recommendations is now due.

3. Consult the problem originator of MS-2, Explosion Detector, on the information from T. N. Marshall at MSFC regarding the digital blast gauge. (Only a portion of this instrument is needed to satisfy MS-2 specifications. But the complete instrument might well be used by Bureau of Mines experts in studies of the properties of explosions.)

4. Submit the report on MS-3, Air-Flow Measurement, now in preparation to the Bureau of Mines, for their consideration of our recommended method of using the ERC device.

5. Discuss with Dr. A. Chambers at Ames Research Center our report on a Fireman's Life Saving System - as a step towards concrete proposals for a Technology Transfer.

E. Planning Activities

Develop specific plans for technology transference activities of the TATeam in respect of each of the potential transfers listed in D.

APPENDIX A

SEARCH EXPERIMENTS

(A report on an experiment to compare the effectiveness of a manual and RDC Search, completed in February 1970).

SEARCH EXPERIMENTS

On February 27, the team began an experiment to compare the effectiveness of the ARAC computer literature search on the detection of indented writing versus a manual search through the 1968 and 1969 STAR indices for the same problem. Mr. Mike Hill, of the Technology Utilization Center's evaluation group, performed the search.

Mr. Hill was given the same type of initial information as the RDC personnel received when the search was initiated; namely, a verbal description of the problem along with some characteristics of relevant technology, the problem statement, and a list of approximately 15 keyword terms. With this information Mr. Hill then searched through the 1968 and 1969 STAR subject indices for relevant report titles. The abstracts for these reports were then reviewed by Mr. Hill to make a final judgement on their relevance. This produced a total of 21 hits for the manual search.

For the purpose of evaluating and comparing the searches, we are defining a "relevant item" as one which is relevant to the problem area (i.e., in the right ballpark) but not necessarily promising as a potential technological solution; a "promising relevant item" is one which appears, on the basis of the STAR abstract, to be a good potential candidate for technology transfer. Also, we are defining the term "Search Quality" as the (No. of relevant items/No. of total hits) X 100%, and "Search Effectiveness" as the (No. of promising relevant items/No. of total hits) X 100%.

The following data is then presented to compare the two searches:

SEARCH PROBLEM: "LE-2, Detection and Recovery of Indented Writing"

MANUAL SEARCH

Search Dates: Feb. 27 - began
March 4 - completed & received

Total Time Spent: 12 man-hours Total Turnover Time: 2 days

Search Coverage: STAR 1968 & 1969 only

No. of Hits: 21 No. Relevant Items in Hits: 16

No. of Promising Relevant Items: 9

Search Quality = $\frac{\text{\# Relevant Items}}{\text{\# Total Hits}}$ X 100% = 76%

Search Effectiveness = $\frac{\text{\# Promising Items}}{\text{\# Total Hits}}$ X 100% = 43%

All Items Produced Were From STAR

Of The 9 Promising Items - 1 is NASA
8 are Non-NASA

RDC SEARCH (ARAC)

Search Dates: Jan. 12 - begun
Feb. 3 - completed & received

Total Turnover Time: 22 days

Search Coverage: STAR - 1962 to 1969
IAA - 1963 to 1969
Tech Briefs - cumulative index

FOR OVERALL SEARCH

Total No. of Hits: 41 Items

Total No. of Relevant Items in Hits: 7

Total No. of Promising Relevant Items: 4

Total Search Quality = $\frac{\text{\# Relevant}}{\text{\# Hits}}$ X 100% = 20%

Total Search Effectiveness = $\frac{\text{\# Promising}}{\text{\# Hits}}$ X 100% = 10%

Of 41 Total Hits: 25 are IAA hits
16 are STAR hits
0 tech briefs

Of 4 Promising Items: All 4 are Non-NASA

FOR 1968-1969 SECTION of RDC Search:

No. of Hits: 13 No. of Relevant Items: 4

No. of Promising Items: 2

('68-'69) Search Quality = $\frac{\text{\# Relevant}}{\text{\# Hits}}$ X 100% = 33%

('68-'69) Search Effectiveness = $\frac{\text{\# Promising}}{\text{\# Hits}}$ X 100% = 13%

Of 2 Promising Items Neither are NASA

COMPARING MANUAL & RDC SEARCHES

	MANUAL		RDC('68 & '69)
No. of Hits	21		13
No. Items Relevant	16		4
No. Items Promising	9		2
Search Quality	76%		33%
Search Effectiveness	43%		13%
Promising NASA Tech Items	1		0
No. of Hits in Common		3	
No. of Common Hits Relevant		3	
No. of Common Hits Promising		2	
Total Turnover Time	2 days		22 days

Note: 3 of the 4 relevant items in the RDC search were also included in the manual search; although the fourth item was not included in the manual search, a nearly identical report by the same author was found in the manual search.

It can be seen that there is a significant difference between the manual and RDC searches in both quality and effectiveness. Also, and probably more important, is the significant difference in the total number of both the relevant and promising items produced by the searches. The manual search apparently has produced a much more comprehensive coverage of the STAR index than the RDC search. This discrepancy is compounded by the fact that nearly all the manual search hits were found by using the same keyword terms as in the RDC search strategy.

There appear to be three possible factors causing this discrepancy:

First, the reports may be keyword indexed for computer storage in some inconsistant way making retrieval difficult.

Second, the team may not adequately communicate the problem to the analyst; perhaps much of the information that is contained in the problem statement is not specific enough for the analyst to perform our type of search.

Third, the problem may lie within the RDCs, themselves.

For the following month, all of the team's searches will be run on RECON. We hope to then evaluate these against past searches by the RDC's, to determine the effectiveness of using RECON directly by the team as a literature search tool.

APPENDIX B

PROBLEM STATEMENTS

Problem Statements issued during the Quarter ending 31 March 1970.

TECHNOLOGY
APPLICATIONS
TEAM

MINE RESCUE COMMUNICATIONS

A problem in Mine Safety undertaken by the
IIT Research Institute team sponsored by
NASA's Technology Utilization Division

This Problem Statement calls to your attention significant technological needs in an important area of concern in the public sector. We hope to bring to bear on this problem the information and expertise that resides in NASA. If you feel you can contribute, please relate your ideas to the Technology Utilization Officer at your installation, or to the team representative named in the statement.

INTRODUCTION

Following the occurrence of a mine disaster, rescue efforts are generally hampered by a lack of information regarding survivors who may be trapped within the mine. The efficiency of rescue operations would be greatly improved if trapped personnel could communicate with those on the surface by means of some sort of emergency signalling system. Present communication links, where provided, between the mine interior and the surface generally offer only limited coverage, and are not designed to survive an explosion or collapse.

STATEMENT OF THE PROBLEM

Emergency signalling devices should be readily accessible to everyone within a mine. This objective would best be met by furnishing each person entering a mine with his own signalling unit. Individual units should therefore be small enough to be carried on the person without discomfort or interference with normal work. The following additional requirements should be met by the emergency signalling system:

1. Range should be at least several hundred feet through rock, soil, water, etc.

2. The cost per signalling unit should be reasonably low--say a few dollars.

3. Each unit should be capable of several hours of continuous operation from its own power source. This, in turn, would probably dictate that average power consumption be held under five watts.

4. It would be desirable that each unit be completely self-contained, with no need to attach external antennas, ground leads, sonic transducers, or the like.

POSSIBLE TECHNIQUES

Among possible techniques which appear promising are the following:

1. Mechanical (seismic).

2. Electrical/magnetic--either direct penetration by means of electrical or electromagnetic signals, or by using existing electrical conductors (wiring, rails, pipes, etc.) as signal-carrying media.

BACKGROUND INFORMATION

Following are some brief observations regarding the applicability of various signalling methods.

1. Mechanical (seismic) - The attenuation of mechanical energy as it travels through rock rises rapidly with frequency. Even at frequencies as low as one kilocycle, attenuation of the order of hundreds of decibels for 1000 foot penetration is typical. This will probably eliminate any but sub- and low-audio frequencies from further consideration. It should be noted that, due to the extremely high attenuation coefficient for loose soil, both sending and receiving devices in a seismic signalling system would have to be placed in intimate contact with bedrock. This could be objectionable wherever topsoil thickness is greater than a few feet.

2. Electrical/magnetic - Two general signalling techniques employing electrical/magnetic propagation appear to merit investigation: (a) carrier systems, utilizing existing electrical conductors within the mine (this would include rails, plumbing, ductwork, etc.); and (b) direct penetration techniques, which would radiate energy directly between the mine interior and the surface.

   Relatively high transmission efficiencies might be realized with carrier communication techniques, so that comparatively low transmitted power levels would be required. Increased reliability would be obtained by utilizing all conducting structures in parallel, with frequent cross-connections between different types of structures. This would provide maximum redundancy in available conducting paths.

Based on the principal mode of propagation, direct penetration techniques can be calssified as electrical, magnetic, or electromagnetic.

An electrical system, which would depend on the conductivity of the rock and soil between the transmitter and the receiver, would require that a pair of electrodes be driven into the earth at each end of the transmission path. For a given transmitted power, the range achievable with such a system is directly related to the electrode spacings. Further investigation will be required to determine whether adequate range could be obtained with reasonable electrode spacings. Effectiveness of such a system is greatest at low frequencies, so that direct voice transmission would be possible with a minimum of equipment.

In a magnetic system, the transmitter and receiver are provided with induction coils which set up and detect a varying magnetic field. As with an electrical system, propagation efficiency decreases with increasing frequency; however, it is somewhat more difficult to provide for voice communication with a magnetic system.

An electromagnetic system (i.e., radio) operating in the ELF or VLF region would be capable of penetrating to great depths. (The Navy uses low audio frequencies to communicate with submarines which are submerged in sea water.) The primary drawback of such a technique is that, due to the long wavelengths involved, extremely large transmitting antennas are required for truly efficient radiation. Nevertheless further investigation would seem worthwhile.

REFERENCES

A literature search of aerospace technology is presently being conducted. A list of pertinent references so far identified in this search is attached. Any additional references you may suggest would be appreciated.

FOR FURTHER INFORMATION

If you need more details about this problem, or if you wish to discuss some of your ideas with a team representative, please contact:

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Reference: MS-5

REFERENCES

1. Ames, L. A., Frazier, J. W., Orange, A. S., and deBettencourt, J. T., "Radio Communications via Rock Strata," IEEE Transactions on Communications Systems, Vol. CS-11, June 1963, pp. 159-169.

2. Corti, E., Franceschetti, G., and Latmiral, G., "Radio Links and Antennas in Boundless or Bounded Lossy Media," January 1967, Contract AF 61(052)-851, AD-650719.

3. Ikrath, K., and Schneider, W., "The Realization of Active Seismic Systems and Their Practical Applications," in Army Department of Army Scientific Conference Proceedings, Vol. II, 1965.

4. Wundt, R. M., and Boots, D. A. "Underground Communications," IEEE Transactions on Communications and Electronics, March 1964, pp. 137-142.

5. "Sub-Surface Communications," Papers presented at the 12th Symposium of the AGARD Avionics Panel, Paris, April, 1966.

TECHNOLOGY
APPLICATIONS
TEAM

IMPROVED CAP LAMP FOR MINERS

A problem in Mine Safety undertaken by the IIT Research Institute team sponsored by NASA's Technology Utilization Division

This Problem Statement calls to your attention significant technological needs in an important area of concern in the public sector. We hope to bring to bear on this problem the information and expertise that resides in NASA. If you feel you can contribute, please relate your ideas to the Technology Utilization Officer at your installation, or to the team representative named in the statement.

WHAT IS NEEDED

A new light source for miners, capable of being incorporated within the safety helmet.

BACKGROUND

In addition to the fixed lighting installed in mines, individual cap lamps are issued to each person entering a mine. The basic design of these lamps has not changed in the last sixty years: the bulb is powered by a belt-carried battery pack, connected by a cable which runs up the back and across the top of the safety helmet. Although the cable does not interfere with normal work, it does constitute somewhat of a hazard, since it can become hooked on protuberances. If the overall weight of the light source can be reduced sufficiently, it can be incorporated entirely within the helmet, eliminating the interconnecting cable. Also, the removal of the battery pack from the belt area would permit carrying other safety equipment, such as a radio transmitter, in its place.

Currently available miners cap lamps employ standard storage batteries and incandescent lamps. The batteries - nickel-cadmium, lead-acid, or Edison type - are enclosed in a separate case, and weigh about five pounds. The lamp bulbs contain two filaments, one of which serves as an emergency spare, and draw between two and five watts.

In order to eliminate the danger that a broken bulb might trigger an explosion in a gassy environment, lamp assemblies are designed so that the filament circuit is opened in the event the bulb is broken.

CONSTRAINTS AND SPECIFICATIONS

The improved cap lamp should meet the following requirements:

1. Overall weight of under one pound.
2. Light to operate for 10-12 hours without recharging.
3. Permissible in explosive atmosphere.
4. Light output of 40-100 lumens.
5. If an electrical system is contemplated, secondary (storage) batteries should be employed, and no corrosive liquids are to be used.

CHARACTERISTICS OF RELEVANT TECHNOLOGY

The most obvious approach to reducing the overall weight of a portable lighting system would be to improve the efficiency of either the power source or the light source, or both. Another possibility might be the use of a non-electric light source (e.g., chemiluminescence). The use of a wireless power transmission system does not appear too attractive, since such a scheme would make all miners dependent on a single power source, and would involve installation of a power distribution/radiation system throughout the mine.

FOR FURTHER INFORMATION

If you need more details about this problem, or if you wish to discuss some of your ideas with a team representative, please contact:

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Reference: MS-6A

IITRI/MS-8

TECHNOLOGY APPLICATIONS TEAM

PREDICTION OF ROOF FALLS IN COAL MINES

A problem in Mine Safety undertaken by the IIT Research Institute team sponsored by NASA's Technology Utilization Division

This Problem Statement calls to your attention significant technological needs in an important area of concern in the public sector. We hope to bring to bear on this problem the information and expertise that resides in NASA. If you feel you can contribute, please relate your ideas to the Technology Utilization Officer at your installation, or to the team representative named in the statement.

INTRODUCTION

Roof collapse results from gradual changes in the rock strata overlying coal mine passages. Casualties due to roof collapse are not publicized like the major mine disasters and therefore do not generate public concern as did the trapping of 78 miners at Mannington, West Virginia. Yet, the U. S. Bureau of Mines estimates that in 1966 alone roof falls accounted for 58% of all fatalities and 15% of all injuries sustained by the subsurface bituminous coal mining industry.

STATEMENT OF THE PROBLEM

A device which can detect and record changes in rock strata may provide advance information of roof failure for initiating preventive action. A suitable device should have the following capabilities:

1. Detect separation between the various strata overlying the roof.
2. Detect and record roof movement especially prior to collapse and provide a warning signal.
3. Detect movement relative to the various faces of the opening as well as with respect to its original position.
4. Stability, e.g. freedom from 'drift,' for long periods of time, say, several months.
5. Ruggedness to vibrations, dust and humidity encountered in coal mines.
6. Permissibility in an explosive atmosphere.

POSSIBLE APPROACHES

The changes in roof strata preceding a roof fall involve the development of stresses and strains and the movement of material (see figure). Some of the characteristics of these changes which may indicate roof movement are:

1. Subaudible noises (microseismims) generated by rock movement. These may be detected by suitable microphones or other acoustic sensors.
2. Relative movement of marked locations with respect to a reference point.
3. Physical properties e.g. resistivity, acoustic velocity, porosity etc.

BACKGROUND INFORMATION

The unstable area over a mine opening spanning the pillars is considered to be dome shaped (see figure). The base of this dome is the mine roof, the dome-height being determined by the orientation and strength characteristics of the roof layers. The unstable rock may be supported to a large extent by timber, beams, and roof-bolts. Such protection may become inadequate if roof instabilities develop subsequently. Furthermore, the virgin roof behind the advancing mine face is a danger area of unknown stability and is, generally, without protection.

Several techniques are currently used for the detection and measurement of rock layer separation and movement. One popular device known as the extensometer measures the distance between a reference point and a marked point on the wall or roof at frequent intervals, by means of a graduated tape, rod, or tube. The reference point is located within the mine opening, and the marked point is the extensometer component anchored in the selected roof stratum. Though extensometers have high precision, they are expensive, nonautomatic in operation, costly to install and incapable of differentiating between the sagging of a roof and the heaving of a mine floor.

Conventional surveying within the mine opening to detect roof movement has the same limitations as the extensometer. A very common method for detecting weak spots in a mine roof is by "sounding" the roof i.e. knocking with a rod or hammer at selected spots. A "hollow" sound indicates cavitation or inter-layer separation and the possibility of conditions for a roof fall. The reliability of the method is limited because it leaves much to the judgement and experience of the foreman.

The feasibility of detecting unconformities and rock layer interfaces overlying a mine roof, by analyzing sonic or ultra-sonic reflections from them, has been studied by the U. S. Bureau of Mines. Frequencies in the range of 1 cycle to 100 KC at transmitter power outputs of 0.1 to 1.5 KW were used. Because of high attenuation of sonic waves by rocks the maximum penetration attained in a test was only 57 inches. None of the methods recounted above, however, can give positive indications of imminent roof-failure.

FOR FURTHER INFORMATION

If you need more details about this problem, or if you wish to discuss some of your ideas with a team representative, please contact:

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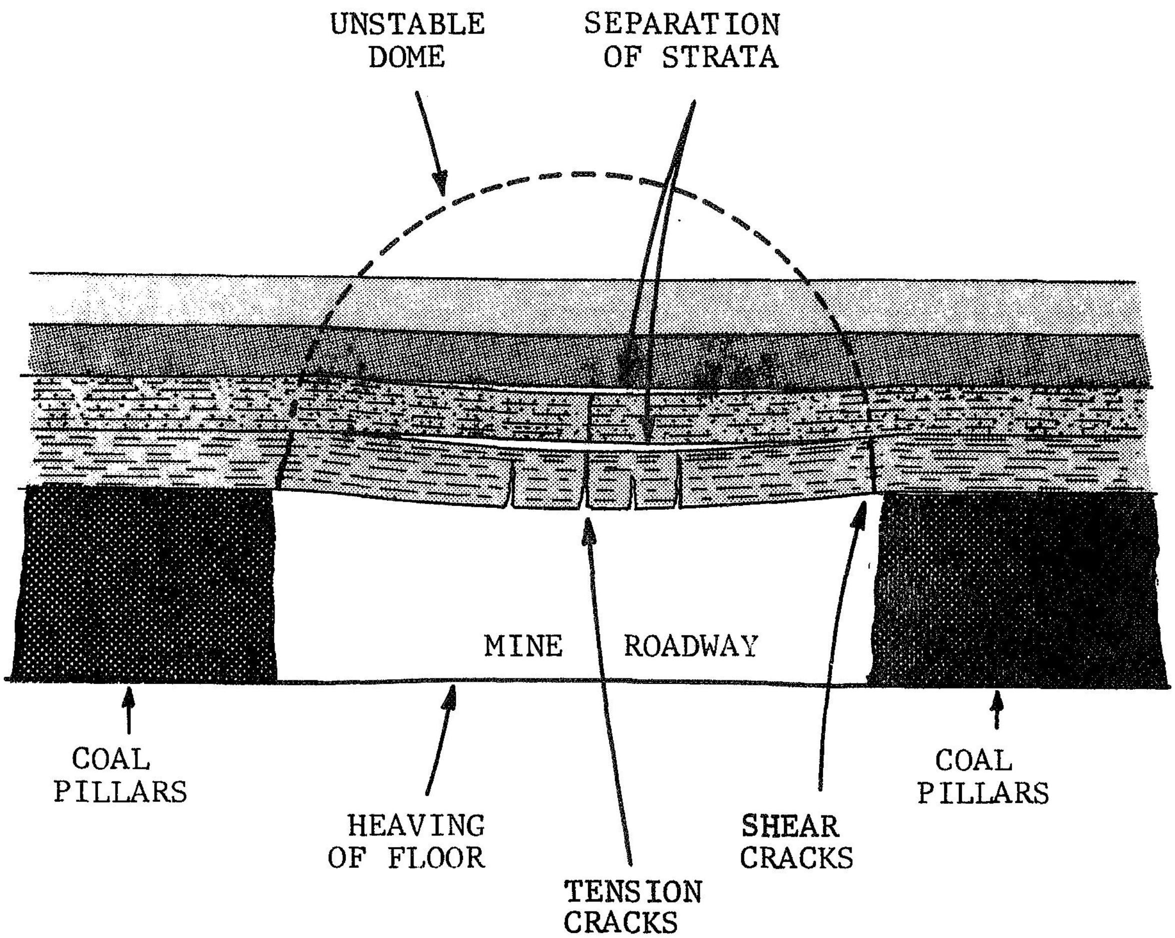
DIAGRAM SHOWING ROOF DETERIORATION
OVER COAL MINE ROADWAY



IITRI/LE-2

TECHNOLOGY APPLICATIONS TEAM

DETECTION AND RECOVERY OF
INDENTED WRITING

A problem in Law Enforcement undertaken by the IIT Research Institute team sponsored by NASA's Technology Utilization Division

This Problem Statement calls to your attention significant technological needs in an important area of concern in the public sector. We hope to bring to bear on this problem the information and expertise that resides in NASA. If you feel you can contribute, please relate your ideas to the Technology Utilization Officer at your installation, or to the team representative named in the statement.

STATEMENT OF THE PROBLEM

The police need a method to examine various types of paper to detect the presence of indented writing, and to reconstruct and record the information it contains.

BACKGROUND INFORMATION

Indented writing is the image of a written message which has been transferred from the original as an impression in the surface of a succeeding layer of material. Very often loose pieces of paper such as note paper, typing paper or other stationery are used as backing sheets for previously written messages. Of course, this is nearly always true for all except the top sheet of a pad of paper. Each time a piece of paper is used as a backing sheet, a portion of the message is transferred to it from the original in the form of indented writing. The police often encounter this type of evidence, for example, in gambling raids where the original copy of telephone numbers and betting amounts has been destroyed but the information is preserved on succeeding pages of a notebook. Depending upon the backing beneath the second sheet, the quality of the papers, the shape of the writing instument, and the pressure applied by the writer, the indented writing in the second sheet is sometimes visible to the unaided eye. But more often than not, the sample of indented writing is too faint to be legible.

In general, an improved technique is most needed to examine a document which contains one or more superimposed messages. While detection of the presence of indented writing in these cases may not be difficult, recovery of the information by techniques presently in use is often impossible.

Techniques presently in general use include various schemes of side-lighted shadow-casting, thermo-setting plastics and several photographic approaches such as the use of high contrast film. These methods are unable to resolve indentations below a certain threshold. The "Hollywood Detective" technique of shading with a pencil is virtually never used in actual practice as it is more likely to destroy the information than aid in retrieving it.

CHARACTERISTICS OF INDENTED WRITING

The mechanism of indented writing has not been totally characterized, but it is primarily a displacement of the paper fibers rather than a compression process, such as is the case with watermarks. As with any forming process, the shape of the indentation is dependent on the shape of the writing instrument.

Rough measurements made on ball pen indentations indicate that when the depth of the furrow is of the order of 2 mils (50 microns) the information can be recovered using shadow lighting. At depths less than 0.6 mil (15 microns) the presence of indented writing can be visually detected but usually not read. These are approximate values and are given only to indicate orders of magnitude. It is not known at what minimum depth the indentations can be visually discerned.

POSSIBLE APPROACHES

Techniques employed to analyze surface imperfections might be adaptable to this problem. Some approaches are:

1. Mechanical measurement of depth of grooves.
2. Holography.
3. Optical reflection from surfaces.
4. Thin-film thickness measurement techniques.

The method employed should be adaptable to scanning an entire page of copy. A visual display of the recovered information is most desirable.

LITERATURE SEARCH

A computerized search of the aerospace literature has been initiated. A number of pertinent references have already been identified and are listed below. However, some relevant technology might not be identified by this means and any additional references you suggest would be appreciated.

1. Surface Irregularities Detected by Flare Inspection Instrument (Fiber Optics), NASA Tech Brief 69-10152.

2. Surface Profilometer for Examining Grain-Boundary Grooves, AEC-NASA Tech Brief 69-10345.

FOR FURTHER INFORMATION

If you need more details about this problem, or if you wish to discuss your ideas with a team representative, please contact:

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Reference: LE-2

IITRI/LE-7

TECHNOLOGY
APPLICATIONS
TEAM

LIGHTWEIGHT GAS MASK AND
FACE PROTECTOR

A problem in Law Enforcement undertaken by the IIT Research Institute team sponsored by NASA's Technology Utilization Division

This Problem Statement calls to your attention significant technological needs in an important area of concern in the public sector. We hope to bring to bear on this problem the information and expertise that resides in NASA. If you feel you can contribute, please relate your ideas to the Technology Utilization Officer at your installation, or to the team representative named in the statement.

STATEMENT OF THE PROBLEM

A requirement exists for a light weight face protector for police which will provide protection both against flying objects (glass, bottles, bricks, etc.) and against smoke and tear gas.

BACKGROUND INFORMATION

Experience gained from civil disturbances over the past several years indicates:

1. A major portion of police casualties result from flying objects such as broken glass, bottles, bricks, and stones.

2. The helmets adopted by most police agencies provide adequate protection to the head, but the face and eyes are not adequately protected. Instances have been recorded where police refused to use plastic visors provided with their helmets because "they cause visual distortion."

3. Tear gas is a relatively successful agent for crowd control purposes, and will unquestionably continue to be used for such purposes.

4. Tear gas, particularly when disseminated by cannisters or grenades, or as a cloud, can affect unproperly protected police as well as the targets against which its use was intended.

Most police agencies are presently using World Wars I and II vintage gas masks. These are generally characterized as being too heavy and cumbersome, as restricting vision, as providing no protection against flying objects, and as being ineffective against type CS tear gas.

ESSENTIAL CHARACTERISTICS

A. Technical

   1. Protector should be effective against smoke and types CN and CS tear gas.

B. Operational

1. Protector should be light weight and easily donned.

2. Protector should cause neither restricted nor distorted vision.

3. Protector should provide protection against flying objects.

4. Protector should not interfere with police activities and movements.

FOR FURTHER INFORMATION

If you need more details about this problem, or if you wish to discuss some of your ideas with a team representative, please contact:

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Reference: LE-7

TECHNOLOGY APPLICATIONS TEAM

RESCUE EQUIPMENT - AUTO ACCIDENTS

A problem in Law Enforcement undertaken by the IIT Research Institute team sponsored by NASA's Technology Utilization Division

This Problem Statement calls to your attention significant technological needs in an important area of concern in the public sector. We hope to bring to bear on this problem the information and expertise that resides in NASA. If you feel you can contribute, please relate your ideas to the Technology Utilization Officer at your installation, or to the team representative named in the statement.

WHAT IS NEEDED

There is a need for tools that will spread or separate materials that are spaced about 1 or 2 inches apart and other materials that are spaced about 1 foot apart. And/or, there is a need for a tool or method of cutting, breaking, or removing steel or aluminum in wrecked vehicles.

BACKGROUND

In responding to automobile accidents the law enforcement officer and/or fire department rescue squad is responsible for the extrication of trapped persons. Tools are needed to separate materials and to cut or break steel and aluminum. Currently hydraulic jacks, separators and chain pullers are used for separation but these tools are too heavy and are not strong enough for many applications. Torches and power saws are sometimes used for cutting but they increase the danger of fire.

Law enforcement and fire department officers at city, county, and state levels are charged with the investigation of automobile accidents and are generally the first help at the scene. If the occupants of the vehicle are pinned or trapped inside, they must be removed so that they can receive proper medical care and are away from fire and other hazards that are prevelent at the scene of an accident.

There are two general types of tools currently used to extricate victims from accident vehicles - prying and separating equipment, and cutting equipment. Crow bars, chains, winches, blocks, wedges, and hydraulic jacks and their attachments (such as Enerpac equipment made by Blackhawk) are used to force apart objects that pin or trap victims. Some of the disadvantages of these tools are as follows:

1. Crow bars can be of danger to the user since the bar may slip and release or break suddenly and cause injury.

2. The hydraulic equipment
    a. will not operate in all positions.
    b. is often too bulky for one person to position and operate.
    c. is heavy to handle and carry to the rescue site.
    d. use screw type connectors take too much time to connect, and sometimes loosen during an operation.

Power and hand saws, axes, and torches are currently used to cut materials. Although power saws and torches are relatively fast to use, they present a high fire hazard due to the throwing of hot sparks or the open flame. Hand saws are also used but they are slower and can also produce sparks.

Often the roof, door, or trunk of the automobile must be removed in order to gain access to the trapped passenger. The structure of these parts is as follows:

<u>Roof Structure</u>

1. Outer body - thickness 1/32 to 1/16 inch

2. Normally one strenthening beam, usually in line with the center post - thickness 3/32 to 1/8 inch or more.

3. Acoustic lining and interior cover.

4. Steel rods (1/8 inch diameter) used to hold the interior cover in place. The rods are not firmly attached.

<u>Door Structure</u>

1. Outer body - thickness 1/32 to 1/16 inch

2. Window mechanism

3. Hinges

4. Door posts

5. Strengthening structure - thickness 3/32 to 1/8 inch or more

6. Interior cover and fiberboard support

Trunk Structure

1. Outer body - thickness 1/32 to 1/16 inch

2. Structural supports - thickness 3/32 to 1/8 inch or more

3. Rear seat

The enclosed set of pictures illustrates some of the problems faced by the rescuers in their work. Figure 1 shows the precarious position taken by some wrecked vehicles. Not only must the rescuer be concerned with the safe removal of the trapped person(s); he must also be concerned about the possible shifting of loads in the vehicle and of the vehicle itself, and the possible injury to himself or others. Figure 3 illustrates the use of a hydraulic separator to pry open the door to the truck cab. Figure 4 shows the stream of hot sparks that is typically thrown by the saw, thus increasing the danger of a fire.

CONSTRAINTS AND SPECIFICATIONS

I. Separation Tools

This system should have the following features:

1. Capable of fitting into a 1 or 2 inch wide space and spreading objects to about 1 foot separation; or capable of separating objects that are about 1 foot apart to about 3 or 4 feet.

2. Portable, operable in any position and in all types of weather conditions (preferably by one person).

3. Not contribute to existing safety hazards.

4. Capacity - 10 to 20 tons.

II. Cutting or Breaking Materials

1. Capable of cutting, breaking, melting, or removing metal or other materials, ie., steel, aluminum, and concrete.

2. Not contribute to existing safety hazards.

3. Portable, and operable in all types of weather conditions and in any position.

CHARACTERISTICS OF RELEVANT TECHNOLOGY

Among the possible approaches which appear to be promising are the following:

1. Smaller, lighter hydraulic pump that can be used in any position
2. Stronger equipment - new alloys, new design
3. Lighter equipment - new alloys, new design
4. Improved quick-connect couplers for hydraulic equipment
5. Water jet machining
6. Embrittlement of steel by a chemical

FOR FURTHER INFORMATION

If you need more details about this problem, or if you wish to discuss some of your ideas with a team representative, please contact:

F. R. Hand, Director
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IIT Research Institute
10 West 35 Street
Chicago, Illinois 60616

Telephone: (312) 225-9630
Extension 5281

Reference: LE-9

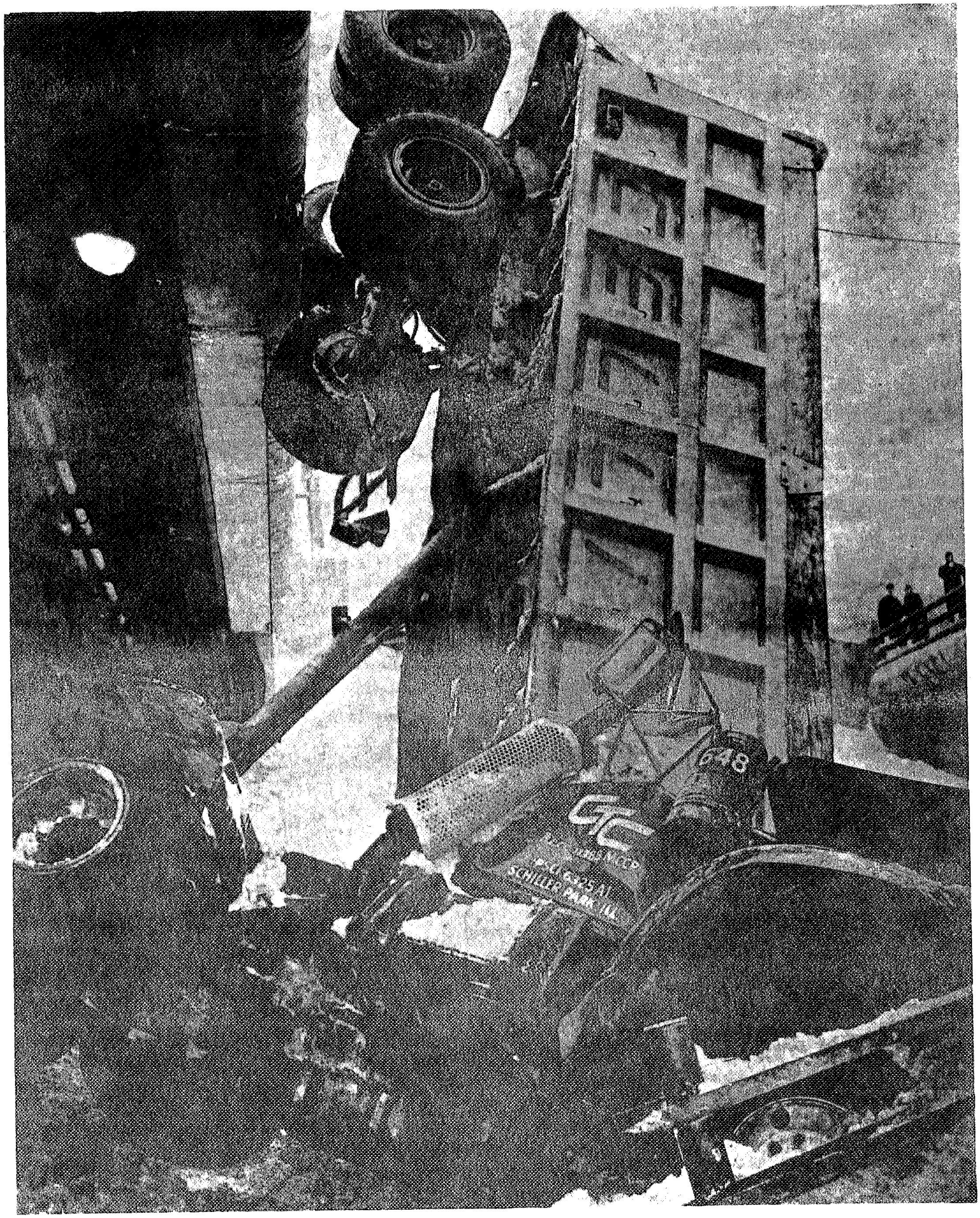

FIGURE 1

OFFICIAL PHOTOGRAPH
Chicago Fire Department

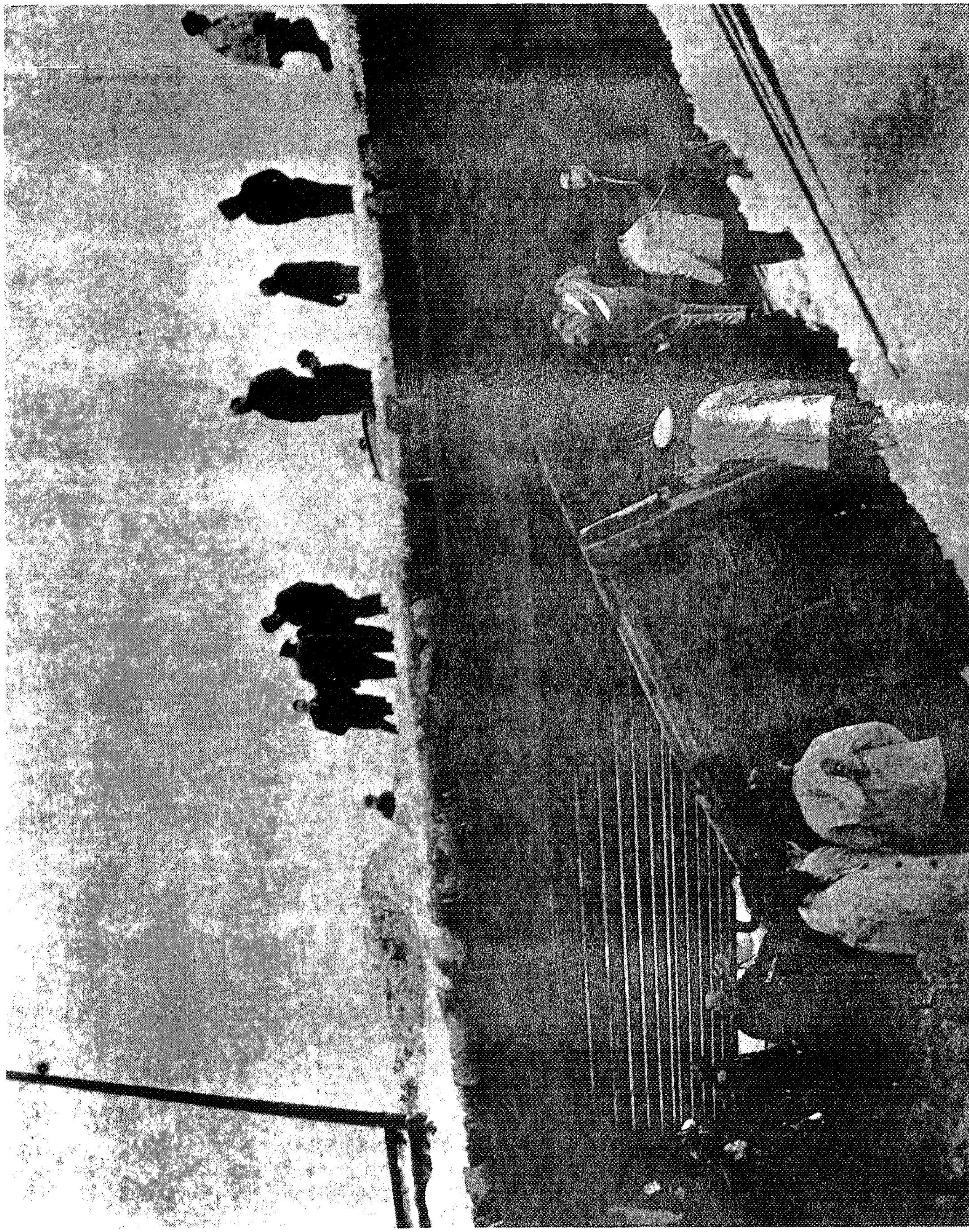

FIGURE 2

OFFICIAL PHOTOGRAPH
Chicago Fire Department

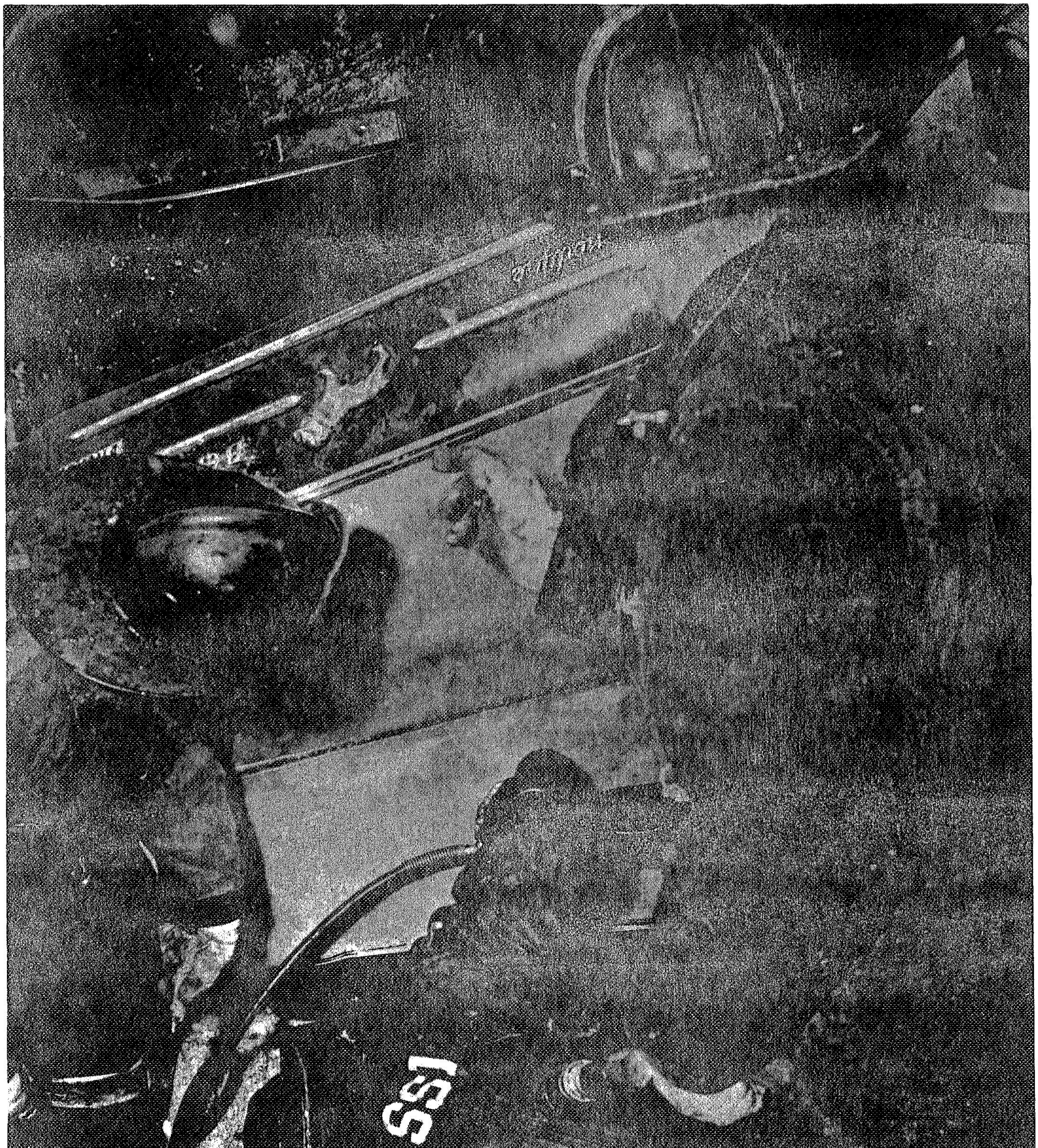

FIGURE 3

OFFICIAL PHOTOGRAPH
Chicago Fire Department

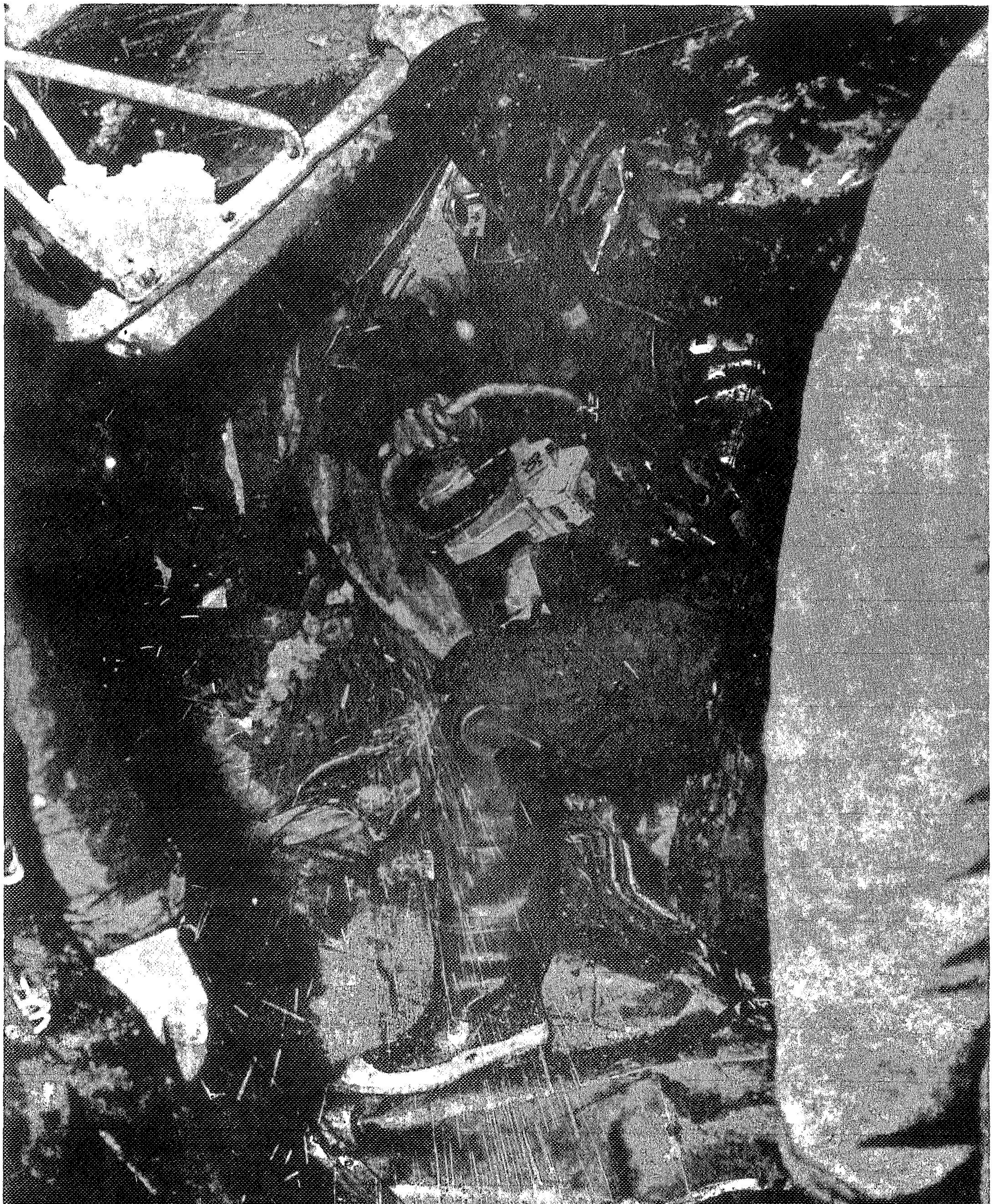

FIGURE 4

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IITRI/WP-1

TECHNOLOGY APPLICATIONS TEAM

RESERVOIR WATER COLUMN DENSITY MEASUREMENT

A problem in Water Pollution undertaken by the IIT Research Institute team sponsored by NASA's Technology Utilization Division

This Problem Statement calls to your attention significant technological needs in an important area of concern in the public sector. We hope to bring to bear on this problem the information and expertise that resides in NASA. If you feel you can contribute, please relate your ideas to the Technology Utilization Officer at your installation, or to the team representative named in the statement.

WHAT IS NEEDED

A device or technique is required which can measure the density of a water column within a large storage reservoir.

BACKGROUND

In the south and southwest areas of the country, many of the local water supplies are contained in large man-made reservoirs. Within the reservoirs, particularly in the larger, highly stable ones (where the water movement in and out is very small relative to the reservoir size), considerable density stratification can take place. This stratification process, which is dependent on the water depth, temperature and chloride concentration, is a serious problem since it can cause the water in the lower section of the reservoir to become anaerobic (oxygen depleted). This condition then renders the water undrinkable causing a potential water supply problem for the area.

The Federal Water Pollution Control Administration may be able to prevent this condition from occurring if the number and location of the stratifications within the reservoir could be detected quickly and easily.

CONSTRAINTS AND SPECIFICATIONS

The required device or technique should meet the following specifications:

1. Be able to measure variations in the specific gravity of water between 1.0000 and 1.0500 with a sensitivity of $\pm$ .00005 - density differences between 62.300 lb/ft^3 and 65.400 lb/ft^3 - at specific locales within the reservoir.

2. The device should be a portable, field type instrument which can be operated at the reservoir.

3. The device should also have the capability of measuring the water temperature in conjunction with the density.

CHARACTERISTICS OF RELEVANT TECHNOLOGY

The required device could incorporate some type of transducer or transducer system which can utilize the measurement of such variables as: force, pressure, differential pressures, and temperature to indicate the water density (or amount of change in the density). There may be optical, acoustic, ultrasonic, and electromagnetic techniques which could also be used.

FOR FURTHER INFORMATION

If you need more details about this problem, or if you wish to discuss some of your ideas with a team representative, please contact:

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10 West 35 Street
Chicago, Illinois 60616

Telephone: (312) 225-9630
Extension 5281

Reference: WP-1

APPENDIX C

AEROSPACE LITERATURE SEARCHES

REPORT ON AEROSPACE LITERATURE SEARCHES FOR PROBLEM LE-3

The experiment comparing the results of the searches on the same problem at both ARAC and KASC is providing additional evidence of our difficulties in carrying out an effective computerized search of the aerospace literature. It was reported in January that the KASC search for problem LE-3 yielded 650 citations while the ARAC search, received just before the end of the month, yielded 102 citations. Examination showed that the latter contained documents only for 1969. This was brought to the attention of the ARAC analyst who, upon checking into the matter determined that the search limit had been set at 100 citations instead of the 1000 he had ordered.

The search was re-run, presumably using the same strategy, changing only the limit on the number of citations. The first batch of new citations was received February 25. It contained 125 citations from the years 1968, 1969, and part of 1970. A comparison of the 1968 and 1969 citations from KASC and ARAC showed:

KASC -	178 citations
ARAC -	117 citations
Common to both -	27 citations
Relevant to problem -	8 citations

Next, a comparison was made for the year 1969 between the two ARAC searches received.

First ARAC search -	102 citations
Second ARAC search -	70 citations
Common to both -	58 citations

The ARAC analyst could not be reached before the end of the month so we do not yet know the reasons for the different results for the two searches. Additional citations are expected for the years 1962 - 1967 in the near future. It will then be possible to compare the entire searches from both KASC and ARAC.

A search was initiated at ARAC on 6 February for problem LE-9, Improved Rescue Equipment. A computer evaluation report appears in Table I. Those documents which appear to be relevant have been ordered and should arrive early in March.

The results of the search for problem LE-2, Detection and Recovery of Indented Writing, were received, also. A Computer Evaluation Report for this search is shown in Table II. Again, only a small percent of the citations appeared to be relevant to the problem, none of which refer to NASA technology. Yet, the cover letter accompanying the citations indicate that the analyst felt that most of the citations were relevant.

The search for problem LE-4, Age and Sequence of Ball Pen Writing, was received and reviewed. The aerospace literature yielded 28 citations, none of which identified technology relevant to the problem. The ARAC analyst, on her own initiative ran a search of non-aerospace literature and turned up 48 documents. These may be of value in revising a search strategy but they yielded no relevant technology.

A Literature Search Experiment

As a result of our experience with the computerized literature searches, the team met to discuss how we can improve the effectiveness of our search procedures. One major concern was our ability to communicate the technical details of the problem to the RDC analyst who must run the search. Often the analyst will indicate that he has filtered the search results and is sending only those citations which he feels are relevant. But our analysis will show, typically, only 5 or 10 percent to be relevant to the problem. Many of the rest are completely off the mark.

TABLE I

Computer Evaluation Report

RDC: ARAC

Search Title: Rescue Equipment for Auto Crashes

Problem Statement: LE-9, Rescue Equipment (Auto Accidents)

Date Search Initiated: 6 February 1970

Search Terms:

A - Caps (Explosives)
B - Hydraulic Jets
C - Chemical Machining
D - Shaped Charges
E - Chemical Effects
F - Water Erosion
G - Explosive Devices
H - Chemical Attack
I - Fluid Jets
J - Ballistics
K - Explosives
L - Slicing
M - Metal Grinding
N - Cutting
O - Grinding (Material Removal)
P - Machining
Q - Embrittlement
R - Brittleness
S - Pushing
T - Separation
U - Expansion
V - Jack (Lifts)
W - Levers
X - Pneumatic Equipment
Y - Hydraulic Equipment
Z - Equipment
AA - Automobile Accidents
AB - Tools
AC - Hardware
AD - Aircraft Accidents
AE - Rescue Operations

Strategy:

(A+B+C+D+E+F+G+H+I+J+K).(L+M+N+O+P+Q+R)+(S+T+U).(V+W+X+Y)+
(Z+AA+AB+AC+AD).(AE)

Date Search Received: 20 February 1970

Results: (analysis not yet complete but 3 look hopeful)

40 citations
8 relevant (3 of NASA origin)

TABLE II

Computer Evaluation Report

RDC: ARAC

Search Title: Detection and Recovery of Indented Writing

Problem Statement: LE-2

Date Search Initiated: 12 January 1970

SEARCH TERMS:

Source Terms:

A - Surface Coating
B - Surface Crack
C - Micro-crack
D - Surface Distortion
E - Shadowgraph
F - Surface Roughness
G - Thin Film
H - Profilometer
I - Reader
J - Measuring Apparatus
K - Detection
L - Indentation

Source Term Strategy:

Weighted term

(A+B+C+D+E+F+G).(H+I+J+K+L)

Thesaurus Terms:

A - Profilometers
B - Readers
C - Detection
D - Measuring Apparatus
E - Micro-cracks
F - Surface Distortion
G - Surface Cracks
H - Surface Defects
I - Surface Geometry
J - Surface Roughness
K - Indentation

Thesaurus Term Strategy:

Weighted term

(A+B+C+D).(E+F+G+H+I+J+K)

Date Search Received: 3 February 1970

Results: 41 total citations
55 not relevant
6 relevant

We decided to see if the problem lies mainly in our ability to communicate the necessary information to the RDC. The team is conducting a manual search using a person not associated with the program but familiar with the resources of the aerospace literature. This experiment and its results are described earlier in Appendix A.

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